

# diversity of shade trees

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# Diversity of Shade Trees on Coffee Based Agroforestry System

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Shade -grown coffee is an agricultural system that contains some forest-like characteristics. However structure and diversity are poorly known in shade coffee systems. In 8 coffee-grown plots of Ngantang-Malang structural variables of shade vegetation and coffee yields were measured recording species and their use.

Coffee stands had four strata with mean density 3381 trees per hectare and at least there were three species on each plot. Diametric distribution resembles of a secondary forest. There is a significant role of shade-grown coffee as diversity refuge for woody plants and maybe associated fauna.

**Key words:** Diversity, shade-grown coffee, vegetation structure, woody plants, agroecosystems.

## Introduction

Biodiversity is one aspect that lately become much attention for his role in maintaining the continuity of the ecosystem. Shade coffee plantations have very diverse biodiversity and capable of maintaining soil conditions, climate, and biology the same as natural conditions [1]. However, many farmers manage coffee plantation with only one type of shade trees for protection. As a result, biodiversity is reduced and consequently erosion, and pest attacks increased.

Shade coffee plantations was important as habitat for flora and fauna [1] and has a complex structure (2) and represents an important biological reservoir for both flora and fauna [3: 1]. However, only a little information about the structural characteristics and plant diversity in coffee plantations that can describe the ideal composition of vegetation and structure from the ecology and economics perception.

This study aimed to determine (1) whether the pattern of management of coffee plantations will affect the species composition, structure and diversity of the coffee plantation (2) the effect of coffee plantation management patterns of population structure of vegetation in coffee plantations, and (3) provide recommendations pattern coffee farm management best able to maintain environmental health.

## II. Materials and Methods

Research was done on coffee-based agroforestry at Ngadirejo and Tulungrejo-Ngantang Malang Regency. Geographically this site was located at 7° 40' - 8° 00' LS and 5° 30' - 5° 40' BT. In this study, it was taken four shade coffee plots and four plots multistrata coffee.

### 1. Data Collection

Vegetation sampling transects were taken at 10 x 20 m<sup>2</sup>. In any plots were recorded type of vegetation tree height, diameter (dbh) and canopy cover. Understorey was identified on 2 x 2 m<sup>2</sup> plot. All types of crops included in the plot were recorded either their types nor abundance.

Vegetation structure was measured by calculating the basal area, canopy percentage, and the abundance of trees and non-coffee coffee. Diversity and richness of species between shade coffee and coffee multistrata calculated and compared by t-test.

Shannon Diversity Index ( $H'$ ) was used to know diversity, and is calculated according to the formula:

$$H' = - \sum_{i=1}^s p_i \log p_i$$

$H'$  = Shannon-Wiener Diversity Index

$p_i$  = proportion of  $i$ -th species abundance or the proportion between the number of individuals species  $i$  ( $n_i$ ) of the total number of individual species ( $N$ ) so that  $p_i = n_i/N$

### III. RESULTS

#### 3.1. Vegetation structure

Vegetation has a complex vertical profile both in shade coffee systems or coffee multistrata. Both of them was found three vertical strata (C, D, E). The lowest strata are dominated by shrubs with a height less than 1 m, while the three other strata are grouped into: 1-4m, 4-20m, 20-30m; and taller than 30m. Each strata has a different species.

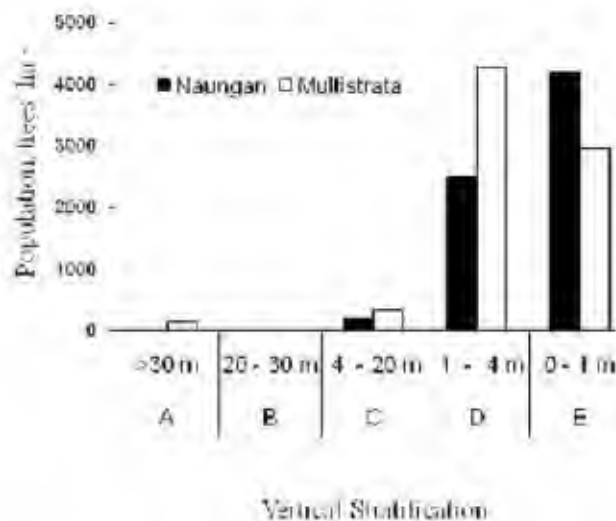


Figure 1. Average population per ha in each of Vertical Strata in the Coffee Garden Coffee Garden Refuge and multistrata

Both systems, simple shade coffee and multistrata coffee, the vegetation is dominated by small size (2 cm < dbh < 10 cm). Almost 90 - 95% sample of individuals in simple shade coffee and multistrata coffee systems has size between 2 cm < dbh < 10 cm, medium-sized 10 cm < dbh < 20 cm is only 4-6% and on simple shade coffee may not find an individual with sized 20-30 cm

Average of trees density was 2525 trees ha<sup>-1</sup> (simple shade coffee) and 4238 trees ha<sup>-1</sup> (coffee multistrata) with an abundance varies from 2250 to 5700 trees ha<sup>-1</sup>. Common shade tree species in this area is gamal (*Gliricidia sepium*), timber trees, or fruit trees. No difference in the two systems both on the total basal area and canopy closure ( $t = 1,34$   $p < 0,05$ ). Average basal area is 7.8 m<sup>2</sup> ha<sup>-1</sup> (simple shade coffee) and 17.5 m<sup>2</sup> ha<sup>-1</sup> (multistrata coffee), otherwise the canopy cover was 61.7% (shade coffee) and 68.6% (coffee multistrata).

Table 1. Structural Variables and Tree Diversity on Simple Shade Coffee and Multistrata Coffee

	Simple Shade Coffee	Multistrata coffee
Struktur		
Density, trees ha <sup>-1</sup>	2525 ± 309,6	4238 ± 1426,8
Basal Area (BA), m <sup>2</sup> ha <sup>-1</sup>	7,8 ± 2,7	17,5 ± 11,9
Total of tree biomass, Mg ha <sup>-1</sup>	29,7 ± 12,9	38,4 ± 18,7
Canopy closure, %	61,7 ± 3,8	68,6 ± 7,6
The average of atmosphere temperature, °C	23,7 ± 0,5	23,1 ± 0,6
Soil temperature (soil depth 0-10 cm), °C	22,2 ± 0,3	21,9 ± 0,5
Diversity		
Species richness	3,0 ± 2,3	11,0 ± 6,8
H' (Indeks Shannon of Species Diversity )	1,0 ± 0,1	1,5 ± 0,3

Note : The value represented the average value ± SD

### 3.3. Vegetation Abundance

Coffee multistrata has 11 species and only three species was found in shade coffee. *Coffea* sp as main crops and *Gliricidia* sp as shade trees has the highest Important Value Index; and bananas at the second order. High value of IVI illustrates their spread and dominance. Average species richness is 3 to 11 species per 200 m<sup>2</sup>. Shannon diversity index in both systems were significantly different ( $t = 4,74$ ,  $p < 0,05$ ) and also shown by different significantly numbers of species ( $t = 4,75$ ,  $p < 0,05$ ).

Plants under the shade coffee system was 33 families where in the coffee multistrata 26 families. Families which are common are Caryophyllaceae, Amaranthaceae, Asteraceae, and Commelinaceae. Dominate species at the two systems are *Ageratum conyzoides*, *Panicum* sp., *Achyranthes aspera*, *Synedrella* sp., *Synedrella nodiflora*, *Dendroenide*, and *Eupatorium riparium*.

Tabel 2. Characteristic Vegetation on Coffe Based Agroforestry

Landuse	Tree Species	Important Value Index (%)	Population/ha	IV
Multistrata	<i>Gliricidia sepium</i>	68,88	2212,5	1,88
	<i>Coffea canephora</i> var. <i>robusta</i>	54,13	1587,5	2,06
	<i>Persea americana</i>	8,92	25	0,15
	<i>Musa paradisiaca</i>	21,58	212,5	0,80
	<i>Erythrina subumbrans</i>	9,22	37,5	0,19
	<i>Duroia zibathumae</i>	9,51	50	0,22
	<i>Anthocephalus cadamba</i> (Miq)	4,76	25	0,10
	<i>Sapindus mirak</i>	4,46	12,5	0,06
	<i>Mangifera indica</i>	4,76	25	0,10
	<i>Parkia speciosa</i> (Hassk)	8,92	25	0,14
	<i>Leucaena leucocephala</i>	4,76	25	0,19



Shade coffee:	<i>Gliricidia sepium</i>	95,43	1287,5	1,91
	<i>Coffea canephora</i> var. <i>robusta</i>	91,47	1187,5	1,94
	<i>Albizia falcataria</i>	13,09	0	0,26

## IV. DISCUSSION

### 4.1. Vegetation Composition and Diversity

Coffee management, will affect the composition and diversity of vegetation. Multistrata coffee has a higher species diversity (9 species), due to farmers' efforts to increase their income, so the dominance of *Gliricidia* sp. as shade trees was replaced with tree species having economic value, such as avocado and durian.

There are 2 types of coffee plantation in our site, ie, shade coffee plantations with *Gliricidia* sp. and shade coffee plantations with a mixture of *Gliricidia* sp., timber trees and fruit trees. This condition is different from the coffee area at Sumberjaya Lampung, which has a coffee plantation shade with three groups, namely, (1) shade coffee farm with fruit trees, (2) shade coffee plantations with woody trees, and (3) coffee plantations with *Erythrina subumbrans* or *Gliricidia* sp [4].

Shannon diversity index is very sensitive to see the dominance of a species (Bone *et al.*, 1997), this means that the low diversity in shade coffee systems associated with high population of individuals *C. arabica*, and *Gliricidia* sp. Index diversity is said low when smaller than 2, medium ( 2-4), and high (> 4 ) [5].

Species richness of coffee plantation are also changing due to management changes where the diversity has increased from 3 to 11 species. Understorey diversity is reduced from 64 species (shade coffee) to 55 species (coffee multistrata). This occurs because the reduction of light entering the bottom so the plant ability to compete taken the light is diminished.

### 4.2. Vegetation Structure

Diameter size distribution (dbh) are often used to show the vegetation structure of a land use [6]. Diameter size distribution patterns show that stands in plot area largely consists of species with a relatively young age, although still found larger diameter on multistrata coffee. Coffee abundance has declined with the increasing population of non coffee species, either timber trees nor fruit trees.

Vegetation structure in the coffee multistrata is more complex due to various types of vegetation with different strata. Vegetation height was less than 20 m, except in the coffee multistrata there were height vegetation more than 30 m. Therefore, stratification type is C, although coffee multistrata has type A. Both systems may not find the B type. This indicates that the system multistrata coffee has more to resemble the structure of forest vegetation due to the multi-layered canopy.

### 4.3. Coffee Structure

Diameter classes of the coffee plant on both systems was similar. Most of the coffee plant has a height between 1.5 – 2 m (88-90%), and only a small portion which has a height > 2.5 m (1-4%). Diameter class 2 < dbh < 10 cm was 46% (coffee multistrata) and 34% (shade coffee). Similar diameter distribution for both of landuse type occur because: (1) Coffee management intensity (frequency of weeding), and (2) land use ; are relatively similar. Population density on multistrata coffee was higher, so there is competition nutrients uptake between vegetation that finally inhibit plant growth. Coffee is still young too, so that farmers are still concentrate on new plants rather than maintain the population structure of coffee.

*Coffea* sp. on multistrata system was lower (34%) than shade coffee (45%), and the *Gliricidia* sp. As shade trees was higher (50%) compared to coffee as a main crop (33-44%).

This is due to farmers perception that the coffee takes time to grow, so they diversify with more economical crops such as timber and fruit crops.

#### V. CONCLUSION

Multistrata coffee and shade coffee has a relatively similar vegetation structure, but not so with the abundance and composition of stands and lower plants. Coffee multistrata more diverse species, although the basal area and canopy closure did not differ because of young age. Therefore, in the long term management plan should be a balanced composition between the percentage of the population and the necessary shade to coffee production is maintained.

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